CLAIMS

1. A method of controlling generated torques of respective torque generation means in the leg body exercise assistive apparatus, which includes leg sections attached to both legs of a person so as to be movable integrally with the legs, with the leg sections each having a foot orthosis portion, which is disposed on the bottom side of the foot of each leg so as to be landing with the foot put on the foot orthosis portion during the landing period, being connected with joint regions corresponding to an ankle joint, a knee joint, and a hip joint of each leg, respectively, along the leg, and the torque generation means capable of generating support torques applied to at least the joint regions corresponding to the knee joint and the hip joint of the leg, the method comprising:

a moment estimation step of sequentially estimating person-side joint moments, which are moments to be generated at least in the knee joint and the hip joint of each leg, in a situation where the person wearing the leg body exercise assistive apparatus is making a motion of his or her both legs, on the assumption that the person is making almost the same motion as the motion of the legs with the leg body exercise assistive apparatus removed from the person, and of sequentially estimating apparatus-side joint moments, which are moments to be generated in the joint regions of the leg body exercise assistive

apparatus corresponding to at least the knee joint and the hip joint of each leg, respectively, on the assumption that the leg body exercise assistive apparatus is independently making almost the same motion as the motion of the person's legs; and

a torque control step of controlling the torque generation means so as to generate a torque, as the support torque, which is obtained by adding a torque determined according to an estimated value of the person-side joint moment corresponding to the joint region concerned to a reference torque, assuming that an estimated value of the apparatus-side joint moment of each joint region corresponding to each of the knee joint and the hip joint of the leg is the reference torque to be generated by the torque generation means corresponding to the joint region concerned.

2. A method of controlling generated torques of respective torque generation means in the leg body exercise assistive apparatus, which includes leg sections attached to both legs of a person so as to be movable integrally with the legs, with the leg sections each having a foot orthosis portion, which is disposed on the bottom side of the foot of each leg so as to be landing with the foot put on the foot orthosis portion during the landing period, being connected with joint regions corresponding to an ankle joint, a knee joint, and a hip joint of each leg, respectively, along the leg, and the

torque generation means capable of generating a support torque applied to the joint regions corresponding to the ankle joint, the knee joint, and the hip joint of the leg, respectively, the method comprising:

a moment estimation step of sequentially estimating person-side joint moments, which are moments to be generated in the ankle joint, the knee joint, and the hip joint of each leg, in a situation where the person wearing the leg body exercise assistive apparatus is making a motion of his or her both legs, on the assumption that the person is making almost the same motion as the motion of the legs with the leg body exercise assistive apparatus removed from the person, and of sequentially estimating apparatus-side joint moments, which are moments to be generated in the joint regions of the leg body exercise assistive apparatus corresponding to the ankle joint, the knee joint, and the hip joint of each leg, respectively, on the assumption that the leg body exercise assistive apparatus is independently making almost the same motion as the motion of the person's legs; and

a torque control step of controlling the torque generation means so as to generate a torque, as the support torque, which is obtained by adding a torque determined according to an estimated value of the person-side joint moment corresponding to the joint region concerned to a reference torque, assuming that an estimated value of the apparatus-side joint moment of each

joint region corresponding to each of the ankle joint, the knee joint, and the hip joint is the reference torque to be generated by the torque generation means corresponding to the joint region concerned.

3. The generated torque control method for a leg body exercise assistive apparatus according to claim 1 or 2, wherein the person-side joint moment and the apparatus-side joint moment estimated in the moment estimation step are moments around an axis substantially perpendicular to a leg plane as a plane passing through the hip joint, the knee joint, and the ankle joint of each leg of the person.

4. The generated torque control method for a leg body exercise assistive apparatus according to claim 1 or 2, wherein the moment estimation step includes: a first step of sequentially grasping an acceleration of a predetermined region of the person or the leg body exercise assistive apparatus; a second step of sequentially grasping displacements of the hip joint, the knee joint, and the ankle joint of each leg of the person; a third step of sequentially estimating floor reaction forces acting on the person and the application point thereof, on the assumption that almost the same motion as the motion of both legs of the person is being made with the leg body exercise assistive apparatus removed from the person; a fourth step of sequentially estimating floor reaction forces acting on the leg body exercise assistive apparatus and the application point thereof, on the

assumption that the leg body exercise assistive apparatus is independently making almost the same motion as the motion of both legs of the person; a fifth step of estimating the person-side joint moment by inverse dynamics calculation processing by using the acceleration grasped in the first step, the displacements grasped in the second step, the floor reaction forces and the application point thereof estimated in the third step, and a person-side rigid link model which represents the person as a link body formed of a plurality of rigid elements and joint elements; and a sixth step of estimating the apparatus-side joint moment by inverse dynamics calculation processing by using the acceleration grasped in the first step, the displacements grasped in the second step, the floor reaction forces and the application point thereof estimated in the fourth step, and an apparatus-side rigid link model which represents the leg body exercise assistive apparatus as a link body formed of a plurality of rigid elements and joint elements.

5. The generated torque control method for a leg body exercise assistive apparatus according to claim 4, wherein:

the person-side joint moment estimated in the fifth step and the apparatus-side joint moment estimated in the sixth step are moments around an axis substantially perpendicular to a leg plane as a plane passing through the hip joint, the knee joint, and the ankle joint of each

leg of the person; and

the acceleration grasped in the first step, the floor reaction forces and the application point thereof estimated in the third step, and the floor reaction forces and the application point thereof estimated in the fourth step are all three-dimensional quantities,

the displacements of the hip joint, the knee joint, and the ankle joint of each leg grasped in the second step each include an amount of rotation around an axis substantially perpendicular to the leg plane of the leg and the displacement of the hip joint is a three-dimensional quantity,

the generated torque control method further comprising:

a seventh step of sequentially grasping an acceleration of a predetermined reference point fixed to a person's predetermined region as a three-dimensional quantity by using at least the acceleration grasped in the first step;

an eighth step of sequentially grasping the positions and postures on the leg plane of the elements of each leg section of the person-side rigid link model by using at least the displacements grasped in the second step and the person-side rigid link model;

a ninth step of grasping the positions and postures on the leg plane of the elements of each leg section of the apparatus-side rigid link model by using at least the

displacements grasped in the second step and the apparatus-side rigid link model, wherein:

the fifth step includes estimating the person-side joint moment by using a two-dimensional quantity, which is obtained by projecting the acceleration of the predetermined reference point grasped in the seventh step and the floor reaction forces and the application point thereof estimated in the third step onto the leg plane corresponding to each leg according to the displacement of the hip joint, and the positions and postures grasped in the eighth step; and

the sixth step includes estimating the apparatus-side joint moment by using a two-dimensional quantity, which is obtained by projecting the acceleration of the predetermined reference point grasped in the seventh step and the floor reaction forces and the application point thereof estimated in the fourth step onto the leg plane corresponding to each leg according to the displacement of the hip joint, and the positions and postures grasped in the ninth step.

6. The generated torque control method for a leg body exercise assistive apparatus according to claim 4, wherein the third step includes estimating the floor reaction forces acting on the person and the application point thereof by using at least the acceleration grasped in the first step, the displacements grasped in the second step, and the person-side rigid link model and the fourth

step includes estimating the floor reaction forces acting on the leg body exercise assistive apparatus and the application point thereof by using at least the acceleration grasped in the first step, the displacements grasped in the second step, and the apparatus-side rigid link model.

7. The generated torque control method for a leg body exercise assistive apparatus according to claim 5, wherein the third step includes estimating the floor reaction forces acting on the person and the application point thereof by using at least the acceleration grasped in the first step, the displacements grasped in the second step, and the person-side rigid link model and the fourth step includes estimating the floor reaction forces acting on the leg body exercise assistive apparatus and the application point thereof by using at least the acceleration grasped in the first step, the displacements grasped in the second step, and the apparatus-side rigid link model.